Statement of Work

for the 2014 Extension of

Ammonium and Nitrate Wet Deposition Models for the

Chesapeake Bay Watershed and Tidal Waters

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The activities and definitions described in this document represent the proposed work plan for the extension and refinement of the Phase II ammonium and nitrate atmospheric wet deposition models from the original 1984-2005 time-span (Grimm and Lynch, 2005; Grimm, 2007) to include a 1983 through 2013 modeling period.

Model Domain

The primary goal of this modeling effort is to produce estimates of atmospheric wet-fall concentration and wet deposition of ammonium and nitrate to the Chesapeake Bay Watershed (CBW) and adjoining tidal waters. However, in order to incorporate a greater number of precipitation chemistry monitoring sites and to reflect the contributions of emissions from a larger geographic region to deposition to the CBW; a larger, surrounding modeling domain will be used. The larger modeling domain will extend from 87.5°W to 66.0°W longitude and from 33.0°N to 48°N latitude. A 1/24th-degree (approximately 5km) grid is superimposed on the larger domain and defines the resolution for grid-oriented model operations.

Data Sources and Procedures

Weekly and daily precipitation chemistry observations from NADP/NTN, AirMON, and PADM network monitoring stations located within the modeling domain and which were are active during 1983 through 2013 will be acquired and quality-controlled for compliance with sampling protocols. From the quality-controlled observation set, a subset of observations representing single precipitation events will be identified and used for subsequent model development.

Output from the NLDAS-2 weather reanalysis model has been designated by the Chesapeake Bay Program as the standardized source for surface weather data for modeling projects. As such, applicable hourly surface weather parameters from NLDAS-2 will be incorporated into this modeling effort. Total and convective precipitation, 2m temperatures, and surface pressure from NLDAS-2 will be used in this model extension project and downward short wave radiation from NDLAS-2 will also be evaluated for use in modeling NOx conversion rates and release rates of ammonia emissions from surface sources (i.e., fertilized fields). The fraction of precipitation occurring from convective events will also be evaluated for use in improving concentration and deposition estimates. NLDAS-2 hourly grids have a native resolution of 1/8th degree and will be downscaled to 1/24th degree resolution by bilinear interpolation for use in our modeling effort.

Additional upper-air parameters will be required to model the atmospheric transport of emissions and to calculate trajectories of precipitation events. Upper-air data is not available from the NLDAS-2 model and will be obtained from the North American Regional Reanalysis model (NARR) instead. The NARR data has an approximate spatial resolution of 1/4 degree and is available in 3-hour time steps. NARR grids will be downscaled to 1/24th degree resolution by bilinear interpolation and hourly values will be derived by linear interpolation between 3-hour NARR model time steps. Minimally, u- and v-wind velocities, vertical velocities, boundary layer heights, and precipitable water values will be incorporated from the NARR into our modeling effort and additional parameters may be considered. Pressure-level parameters (e.g., wind and vertical velocities) will be extracted at 1000, 950, 900, 850, 800, 700, and 600mb heights.

Land cover and land use data will primarily be derived from the 1992, 2001, 2006, and 2011 National Land Cover Databases (NLCD). The availability of multiple NLCD issues during the latter portion of the modeling period is expected to improve the accuracy of the land use parameters used in our model

development. Earlier versions of the Multi-Resolution Land Characteristics land cover datasets are not directly comparable to the subsequent NLCD issues. An effort will be made to estimate land use composition for years prior to 1992 using the 1992 NLCD data in combination with other measures of anthropogenic land use activity (e.g., annual NASS estimates of crop and livestock production, population census data). As in our earlier modeling efforts, 30m resolution NLCD grids will be reclassified into croplands, potential livestock production areas, residential areas, industrial and commercial sites, and transportation corridors. The proportional composition of the major land use categories within and surrounding each 1/24th-degree model domain grid cell and monitoring site location will be calculated and used in modeling the spatial distribution and output of emissions sources, ionic wet-fall concentrations, and wet deposition rates.

County- and point-level estimates of ammonia and nitrous oxide compound (NOx) emissions will be primarily taken from the EPA National Emissions Inventory (NEI) summary series from 1990 through 2011. Estimates of emissions levels for years prior to 1990 will be adjusted based on the national NEI Air Pollutant Emissions Trends Data for Tier 1 CAPS. County-level nonpoint emissions estimates from NEI databases will be spatially apportioned to model grid cells based of the relative composition of land cover and land use derived from the NLCD data sets. EPA fertilizer application data will also be used to define the location and intensity of ammonia emissions. As with the county-level NEI emissions estimates, the spatial distribution of fertilizer applications among model grid cells will be calculated based NLCD land use composition estimates. The timing and relative level of emissions release rates from fertilizer applications will be determined using NASS crop phenology data, soil temperatures, and, possibly, downward shortwave radiation fluxes. Additional sources of ammonia and NOx emissions, such as Mobile-4 and CMAQ emissions inventories for point and non-point sources, will be sought and evaluated for use in this model extension project.

The emissions transport model will be run for the entire model domain grid for the duration of the 1983 through 2013 modeling period in a continuous series of 1-hour time-steps to estimate ambient atmospheric concentrations of NOx compounds and ammonia. Emissions release rates from croplands will adjusted seasonally as described in the preceding section. NOx emission rates from facility power production sources will be seasonally adjusted according to variations in heating and cooling demands. Emissions rates for on-road transportation sources will also be adjusted to reflect seasonal changes in vehicular traffic volumes. Precipitation event back-trajectories of 6-, 12, and 24-hour durations will then be calculated in 1-hour time-steps for each precipitating air parcel to estimate exposure of the air mass to transported emissions.

Linear multiple regression analyses will be performed using the single-event precipitation ammonium and nitrate concentrations obtained from NADP/NTN, AirMON, and PADM monitoring sites as dependent variables against a set of predictor variables representing long-term trends, seasonality, surrounding land use composition, precipitation event volume, antecedent precipitation volume, latitudinal and longitudinal gradients, emission source proximity, and event back-trajectory exposure to transported emissions. The best fitting model will identified for ammonium and nitrate concentrations in precipitation and used to estimate daily wet-fall concentrations and wet depositions for each cell in the modeling domain grid for the duration of the modeling period.

Daily estimates of ammonium and nitrate wet deposition will subsequently be accumulated into annual totals and verified against annual deposition records from NADP/NTN, AirMon, and PADM sites. Only deposition records from monitoring sites meeting annual reporting completeness levels of at least 75 percent will be used for model output verification. Time series plots showing both reported and estimated annual wet deposition values at monitoring sites with long spans of complete monitoring report activity (e.g., PA42) will also be generated and used to evaluate the model output.

Annual and daily ammonium and nitrate wet deposition fluxes to CBW sub-basins and to land and tidal water segment polygons will be generated by aggregating corresponding deposition estimates from the 1/24th-degree model grid and delivered to the Chesapeake Bay Program Office.

A final report detailing the model development and model output verification will be prepared and submitted to the Chesapeake Bay Program Office. Subsequent publication of the model development and application will be pursued and will include acknowledgement to EPA for funding and credit for technical and data contributions to the modeling project.

Expected Project Completion Time

It is anticipated that seven to eight months from the start of project work will be required to produce deliverable deposition estimates to the Chesapeake Bay Program. An additional one to two months will be required for preparation and submission of the final report to the Chesapeake Bay Program.

Project Costs

Costs for development of the extended ammonium and nitrate deposition models, model verification, production of model data deliverables, preparation of the final project report, and for computational and data storage resources will be $47,600.

Literature Cited

Grimm, J.W. and J.A. Lynch, 2005. Improved Daily Precipitation Nitrate and Ammonium Concentration Models for the Chesapeake Bay Watershed. Environmental Pollution 135(2005):445-455.

Grimm, J.W, 2007. Refinements to the Daily Ammonium and Nitrate Wet-Fall Concentration Models for the Chesapeake Bay Watershed. Final Report to United States Environmental Protection Agency, Chesapeake Bay Program Contract No. EPO63000212. 97p.